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The pause/play button actor-network: lecture capture recordings and (re)configuring multi-spatial learning practices

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ABSTRACT

Lecture recording is an increasingly common practice in UK universities, whereby audio, video, and multimedia content from lecture theatres can be captured and distributed online. Despite a large body of recent lecture capture literature, much of the empirical research adopts positivist paradigms, which overlooks the complex and unpredictable nature of teaching and learning. Addressing this knowledge gap, this exploratory case study adopts sociomaterial approaches, specifically perspectives from the domain of actor-network theory (ANT), to view learning technologies as complex assemblages involving heterogeneous human and non-human entities or *actors*.

This paper explores the entanglements involved in enacting online pedagogy and learning across spatiotemporal dimensions using trace ethnography and visualisation mapping. Examining the student-led study practices revealed that multitasking and fluid task switching, between contrasting networks and spaces, was a significant activity during the playback of lecture recordings. Exploring an innocuous and ubiquitous practice, such as video pausing, affords nuanced perspectives into the sociomaterial entanglements involved in enacting study practices. Moreover, adopting multimodal sensitivities reveals how often overlooked modes, such as iconography, can become actors within an assemblage. This may offer new insights into how modes help produce or stabilise configurations and advance efforts in attending to the non-human within actor-networks.

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Introduction

Lecture recording, using semi-automated systems, is an increasingly common practice in UK universities, having grown significantly in recent years. Such lecture capture solutions typically produce digital audio and/or video recording of lectures, usually synchronised with displayed lecture materials (such as digital files and presentations), which are subsequently published online via institutional Virtual Learning Environments (VLEs) (Newton, Tucker, Dawson, & Currie, 2014). In 2018, 75% of UK universities reported having institutionally supported lecture capture systems (Walker et al., 2018). Within such institutions, lecture capture technologies are increasingly employed in large undergraduate classes (Witthaus & Robinson, 2015). The recent interest in lecture capture has been partly attributed to lowering financial costs associated with lecture capture technologies, increased student access to computers and smart mobile devices, greater availability of broadband connectivity, and strong student demand (Newton et al., 2014).

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However, such systems raise a number of issues related to how lecture capture is used as an educational resource. Much of the recent lecture capture literature focuses on quantitative measures of change, such as student attainment or physical classroom attendance (Karnad, 2013; Nordmann & McGeorge, 2018; Witthaus & Robinson, 2015). Such empirical research around lecture capture is largely offered in the positivist tradition, which views teaching and learning as observable, measurable and quantifiable, rather than complex and unpredictable (Wahyuni, 2012). Such research may be seen as oversimplifying the multifaceted workings of lecture capture, which is little acknowledged or explored in the current literature (Morris, Swinnerton, & Coop, 2019). Addressing this knowledge gap, this paper offers an exploratory case study which explores how students' learning practices, involving lecture recordings, are enacted using sociomaterial approaches; a position which appears to be currently absent within existing lecture capture literature. Influenced by perspectives offered by actor-network theory (ANT) this paper also seeks to contribute to the evolving body of sociomaterial literature offered by educational researchers through an account of the novel methodology deployed here. This paper also explores the coupling of ANT with multimodal sensitivities, which may give nuanced insights into how teaching and learning practices are enacted, across spatiotemporal dimensions.

Actor-network theory

By adopting a sociomaterial perspective, underpinned by key concepts from ANT, research sensitivity here was orientated towards accounting for lecture capture practices that are “in the making” (Law, 2009). This position illuminates the heterogeneous “things”, such as people, artefacts, tools, documents, and objects, involved in shaping and enacting practices. ANT is not seen as a concrete explanatory theory but offers methods and perspectives for understanding the “messy practices” (Law, 2009, p. 142) involved in empirically grounded cases. Moreover, ANT brings into focus heterogeneous *actors* – objects of all kinds – and seeks to de-centre the human and the social in educational issues.

ANT studies deploy a unique vocabulary to describe how networks operate and (dis)connect, which are not easily decodable or intuitive (Cressman, 2009). ANT terminology can be problematic and lead to misunderstandings, whereby alternative metaphors to describe actors and networks have been introduced in the literature (Fenwick & Edwards, 2010). Such terminology will be used throughout this paper and are therefore worth exploring for clarity.

Heterogeneity/symmetry

A key feature of ANT centres on removing distinctions between the human and the non-human, the social and the material, culture and nature and so on. Such distinctions are of no analytical importance; rather researcher sensitivity is directed towards the agency of different entities – or *actors* – and the actions they perform, who they (dis)connect with, and the effects of such interactions. Latour (1992, 2005) has debated substituting the more human-centered concept of *actor* with that of the more agency-reminiscent term *actant*, in an attempt to avoid conceptual human-centeredness. However, the term *actor* still prevails in recent literature and for matters of clarity the terms *actant* and *actor* are used interchangeably and as synonyms in this paper. Actants are defined as “entities that do things” (Latour, 1992, p. 241), emphasising the *generalised symmetry* (Callon, 1986) between humans and non-humans (e.g. tools, programmes, documents, objects, machinery, technologies).

Relationality/associations

Importantly, ANT recognises actants, or actors, as not being single entities and are non-existent by themselves. Instead actors exist within an assemblage of materials, brought together and linked to perform a particular function (Callon, 1986; Latour, 2005). ANT positions all actants as being capable of exerting force and joining together in a network, capable of changing and being

changed by each other to form (provisional) stability. Thus, networks are dynamic entities that are constantly the object of (re)negotiation, emerging through enactments, relations and associations between assemblies of material “things”. The relationalism between actors, to perform a particular function and form instances of (momentary) stability, is what ANT scholars have termed a *network* or *assemblage* (Latour, 2005).

Such relationalism also allows for reversibility between the terms *actors* and *networks*, whereby an actor should always be considered simultaneously as a network itself, hence the hyphenated term actor-network (Latour, Jensen, Venturini, Grauwin, & Boullier, 2012). Latour (2005) provides a useful illustration of the dualistic characteristics of actor-networks in an example of the lecture theatre, which is of specific importance here. The lecture theatre can be viewed as bounded entity, or *black box* (Callon, 1986), as well as a complex and heterogeneous network, accumulating actors such as the lecturer, presentation scripts, students, a computer, seats, a projection screen, and so forth. Equally, however, it is possible to conceive each of these actors as being networks in/on themselves. For example, the lecturer is a network consisting of different actors, including the lecturer’s clothes, laptop, lecture notes, curriculum guides, and so on. All these actors, within the lecturer actor-network, bind together in a particular way and (co)define who the lecturer is within specific moments of association.

Actor-networks and mobility

ANT exposes networks which can expand and flow across spaces, distances and/or time (Fenwick & Edwards, 2010). ANT conceptualises space as contingent and spatiality is thus examined explicitly here in relational terms, whereby space is active and undergoing continual (re)constitution (McGregor, 2004; Murdoch, 1998). ANT scholars argue that spatiotemporal dimensions can be understood in network terms whereby space is “identified by the pattern of relations of which it is made up” (Sørensen, 2009, p. 76). Similarly, temporal dimensions are forged within network colorations, whereby there is a simultaneous interaction between the sociomaterial in the immediate environment and with the sociomaterial that is spatially and temporally removed from the situation, but are no less present in effect (McGregor, 2004; Nespor, 1994). As Nespor (2003) argues:

The space of the classroom is extended into the student’s residence, and the student’s out of school time is synchronized not just with the professor’s pacing of course materials, but also to an institutional calendar, which organises ‘learning’ into arbitrary units of time like semesters. (p. 94)

The concept of *immutable mobiles* is key to early ANT scholarship (Latour, 1986) and is one way to describe how networks begin to flow in/on themselves. Immutable mobiles act at a distance and are easily transportable actors which maintain their identity or inherent characteristics between networks, allowing information flow from one actor-network to another. Law and Singleton (2005) argue that it is irrelevant whether the immutable mobile is tangible (e.g. a textbook) or abstract (e.g. a pedagogical strategy). The key feature is that such actors are identifiable and flow, unchanged, between particular network configurations. Immutable mobiles are relevant here as they are seen as “important dynamics in the power relations circumscribing education” (Fenwick & Edwards, 2010, p. 18), which can assessable powerful centres that accumulate thick webs of heterogeneous actor-networks.

Research design

Actor-network theorists assert that in order to understand practices researchers need to “undertake the analytical and empirical task of exploring possible patterns of relations, and how it is that these get assembled in particular locations” (Law, 2009, p. 157). Such a position requires an account of the heterogeneous actors entangled within the studied phenomenon and the relations between different actors. To follow the distributed agency of heterogeneous actors and explore their (dis)connections, this study adopted trace ethnography and visualisation mapping techniques (Decuyper &

Simons, 2016a; Latour et al., 2012). The study was informed by data provided by one academic participant and three student participants, enrolled on an undergraduate engineering programme at a Russell Group university; an association of twenty-four public research-intensive universities in the United Kingdom. The study reports on the student practices involving one lecture capture recording, with a duration of 34 minutes and 13 seconds (Figure 1).

Ethnographic research is seen as a suitable methodology in the studying of sociomaterial phenomena (MacLeod, Cameron, Ajjawi, Kits, & Tummons, 2019; Nimmo, 2011). Ethnography seeks to provide detailed descriptions of “undisturbed” natural settings and assemble accounts by trying to obtain an “insider’s view” into the studied phenomenon. Moreover, this research adopted perspectives offered by multi-sited ethnography, which advocates following people, connections, associations, and relationships across spaces (Coleman & von Hellermann, 2011). Here, research data is linked across different spaces and times instead of focusing on one site and assuming it to be a bounded entity.

Screen recording with video

Guided by an ethnographic desire to gain an insider perspective, an approach to empirically observe the student-led practices involving the lecture capture artefact was required. Screen recording software has been previously employed by researchers as a tool to capture the on-screen activities of participants alongside recordings of real-time interactions via a webcam (Bhatt & de Roock, 2014; Geisler & Slattey, 2007). The student participants in this study were invited to capture their screen actions, with embedded video, using the software tool Panopto (Figure 2). The video data collected amounted to a total of over 160 minutes and produced a rich multimodal rendition of the students’ situated activities, on- and off-screen. In doing so, it provided unprecedented access “from within the members’ practices” (Fenwick & Edwards, 2010, p. 154), across spatial–temporal configurations. Individual semi-structured interviews, with each of the three student participants, were also conducted.

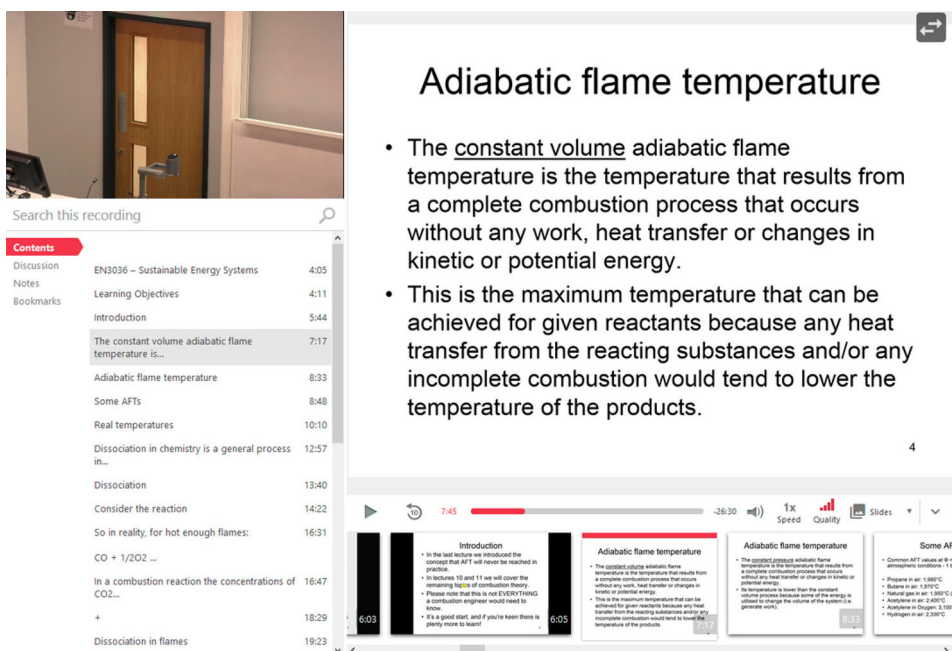


Figure 1. The lecture capture artefact with navigation menu (left) and thumbnails (bottom right). Reproduced with permission of the publisher, © Panopto.

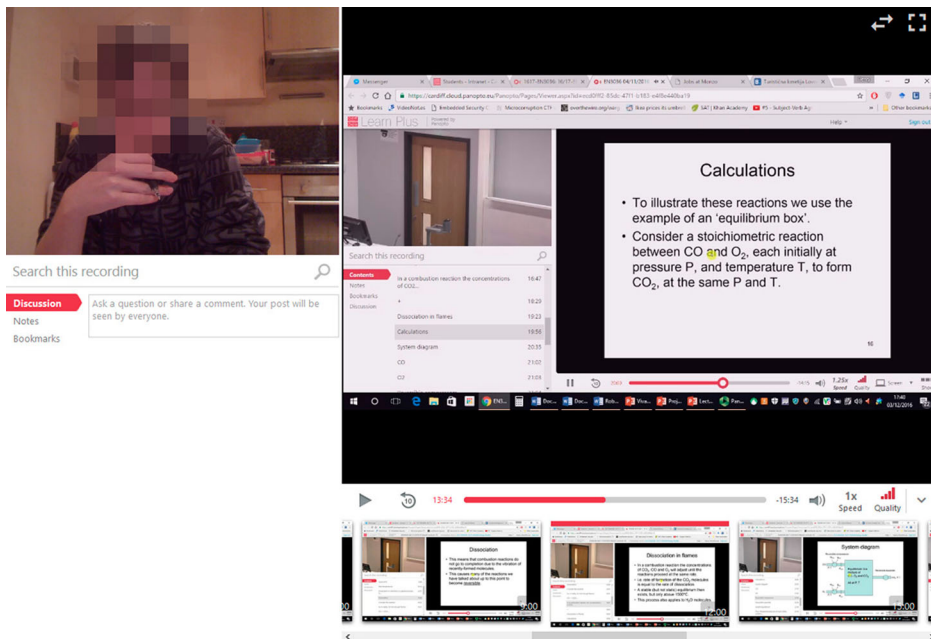


Figure 2. Example of a screen capture artefact, produced by a student participant, with picture-in-picture display. Reproduced with permission of the publisher, © Panopto.

The interviews explored the ways in which participants perceived and enacted practices involving lecture recordings in their lifeworlds.

Multimodal analysis of student produced data

The screen recordings attractively lent themselves to multimodal analysis (Jewitt, 2014; Kress, 2014). Multimodal analysis presents a critical framework to decode and “read” texts and was deployed in an attempt to obtain a nuanced view when analysing non-human actors, such as tools, texts and objects. By analysing the screen recorded actions of the participants, from a perspective of multimodality, allowed the researcher to expose multimodal elements (e.g. navigational buttons, icons, text, images, framing) and explore their connectedness in the observed activities. A textual narrative was produced to document the observed actors, interactions, and relational effects presented in the student-produced videos. All observer notes were coded using theoretical thematic analysis (Braun & Clarke, 2006) for instances of actor-networks and their relations. Analysing the actor-network codes collectively also exposed patterns and combinations in forming overarching themes.

Tracing and mapping

Trace ethnography and visualisations representing actor-networks has been scarcely used in socio-material studies but is seen as a valuable technique in following the distributed agency of heterogeneous actants and scrutinising compositions (Decuyper & Simons, 2014; Latour et al., 2012; O’Keeffe, 2016). Drawing upon the field of visual network analysis, visualisation mapping techniques were deployed to analyse the collected data (Brughmans, 2010; Knox, Savage, & Harvey, 2006). Actors were depicted visually as a set of vertices, or *nodes*, relating to the concept of *punctualization*, which “converts an entire network into a single point or node in another network” (Callon, 1991, p. 153). An undirected interaction line, or edge, was set between nodes each time some kind of action occurred

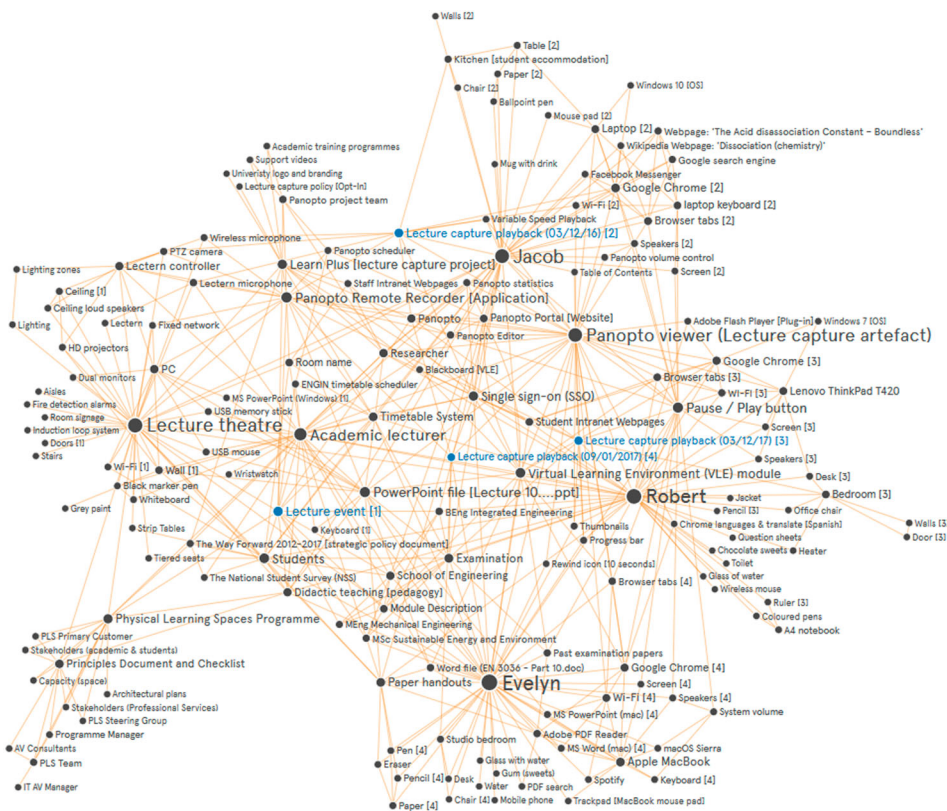


Figure 3. Visualisation mapping of the research data, depicting nodes and interaction edges.

between two (or more) actors. The produced visualisations ([Figure 3](#)) were integral to the study investigation and instrumental in probing the distributed areas of lecture capture practice (Decuypere & Simons, 2014; Latour et al., 2012).

Findings

Sociomaterial network effects: note-taking and sociomaterial arrangements

Despite the notion that lecture capture offers “student-centric” approaches to teaching and learning (Karnad, 2013), a sociomaterial perspective reveals a dichotomy whereby the systems of power emerging from the university fundamentally shape and structure interactions with the recorded artefact. Student viewing of lecture capture videos was a key activity in preparation for a forthcoming exam (Figure 4).

Statistics provided by the lecture capture system revealed a peak in cohort access and playback of the lecture capture artefact in the two weeks prior to the exam (Figure 5). This is foreshadowed in the lecture capture literature, which suggests that students make greater use of lecture capture recordings as a revision tool in the days preceding examination (Elliott & Neal, 2016; Karnad, 2013; Witthaus & Robinson, 2015). The course examination profoundly mediated the *student – lecture recording* interaction, as does the use of Single Sign On authentication whereby the artefact is restricted to enrolled students on the course. From an ANT perspective, the examination not only shaped the content presented in the original lecture event but also mobilised the lecture capture actor-network into the student learning practices, outside of the lecture theatre environment.

How the module will be delivered

Lectures illustrated by formal examples are used to explain the basic principles and applications (two hours per week)

Less formal example/tutorial classes are used to help students apply the knowledge and understanding gained from the lectures (1 hour per week)

Students are expected to devote a minimum of 3 hours per week to private study, attempting a comprehensive set of tutorial problems, the outline of which is given in the tutorial classes. Wide ranging reading around this multidisciplinary subject is expected.

Skills that will be practised and developed

- Appreciate the mechanism associated with combustion and renewable energy systems
- Appreciate the associated terminology
- Apply the basic scientific principles to a range of practical energy systems
- Appreciate the relationships between given energy systems and emissions/pollutants
- Acquire an understanding of the principles and mechanisms that are used to analyse and evaluate energy systems.
- Analytical and problem-solving skills applied to complex systems involving scientific disciplines

How the module will be assessed

The module is assessed through a 2-hour formal examination during the Autumn Semester Examination period.

The examination paper contains one compulsory question, which is subdivided between combustion/pollution and renewable energy/energy policy. This question is awarded one third of the total marks and ensures that students have knowledge of all the material presented in the course. There are four other questions, two each on combustion/pollution and renewable energy/energy policy and students have to attempt two more questions from this four. Each of these other questions also counts for one third of the total marks.

Students are also expected to attempt all the tutorial sheets issued throughout the module in preparation for the example classes and to broaden their understanding of engineering problems. Successful completion of all the tutorial examples assists students towards meeting the desired learning outcomes.

Assessment Breakdown

Type	%	Title	Duration(hrs)
Examination - Autumn Semester	100	Energy Studies	2

Syllabus content

- Current Energy Sources
- Combustion Processes
- Basic principles of combustion, chemical reactions, stoichiometry, properties and air requirements.
- Flames-formulae for flame length. Premixed flames - differences from diffusion flames.

Figure 4. Module description detailing module delivery and assessment requirements (taken from the module area within the institutions’ Virtual Learning Environment).

Reviewing the student-produced screen recordings revealed that note-taking by the student actors was a key activity mediated by the lecture capture artefact and was instrumental in shaping their sociomaterial study practices (Figures 6 and 7). This practice can be viewed in terms of a complex sociomaterial arrangement, involving diverse spaces and many interacting actors. Vignette 1 illustrates how one student organised and structured note-taking activities, which vividly acknowledges the active roles played by heterogeneous actor-networks, such as lecture notes, a notepad, past examination papers, a desk, a chair, coloured pens, the Virtual Learning Environment (VLE), intra-net webpages, Single Sign On authentication, and lecture capture artefacts.

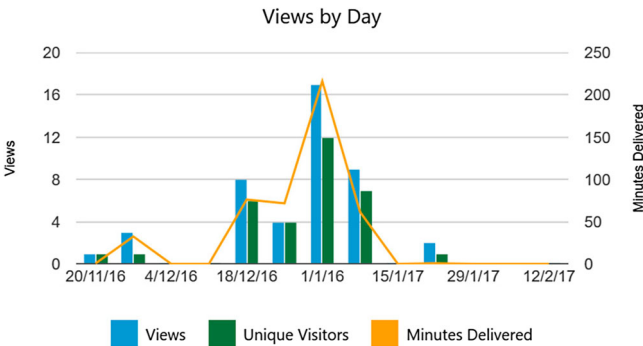


Figure 5. Video analytics showing amount of lecture capture views during the examination period, which took place on 12/01/17. Reproduced with permission of the publisher, © Panopto.

- ② *quieres más* higher means 4 menos turbulencia
- ③ capture air from the turbine
no captura la fuerza de la hélice.
- ④ now mainly power from that disc can I capture
- ⑤ Esta fórmula te va a dar la gráfica.
- ⑥ below 5 m/s no pasa nada → pasando esto cambia
- ⑦ Checa la velocidad y limitan la cantidad de power para controlarlo.
- En este caso lo limitaron a 12 m/s que da unos 1000 kw
- ⑧ the velocity changes slowly. Pressure changes fast.
- ⑨ ^{the Bernoulli's theory} is a energy balance equation
- ⑩ *porque* I am not interested
- nunca vamos a tener más de $\frac{16}{27}$ de the power of that wind
- Betz limit
- Maximum velocity rate is 1.3a
- ⑪ rear.
- you will always want to operate your wind power in this section
- ~~because~~ ~~because~~
- ① The wind is full of turbulence, you get dif. force 4-120V
allow the turbine change speed vel still by that gives →
por eso todas las turbinas de ahora son turbinas with variable speed.
- ② físicamente cambiar la orientación de los blades y así disminuir el reaction force
- Pitch regulation: cambiar el blade para disminuir la fuerza de reacción
- ③ you start with a low speed y va incrementando
- ④ así se ve el modelo final

Figure 6. Example of notes taken by student participant 3.

I had the printed notes from the lectures with me and some question sheets. I had other notes which, like in this book here, are my written notes. I had some old past papers as well. I've got a big desk which is well over a metre wide and two thirds deep in the corner of my room. I've got a nice office chair. And I also had my rulers and coloured pens and pencil and stuff like that which I just keep sort of on the desk so when, well you can see the notes here, that helps me remember things. And I write certain things which are critical. I write them in different colours. Then I went onto Learning Central [Virtual Learning Environment], the university website, signed in, went to the modules and then chose the Panopto [lecture capture tool] section. (Vignette 1; Student participant 1)

Previous studies have reported that note-taking is a significant activity for university students when watching lecture recordings and such study practices can support self-regulated learning of previously-taught material (Morris et al., 2019; Nordmann et al., 2018). Studies report that the technical

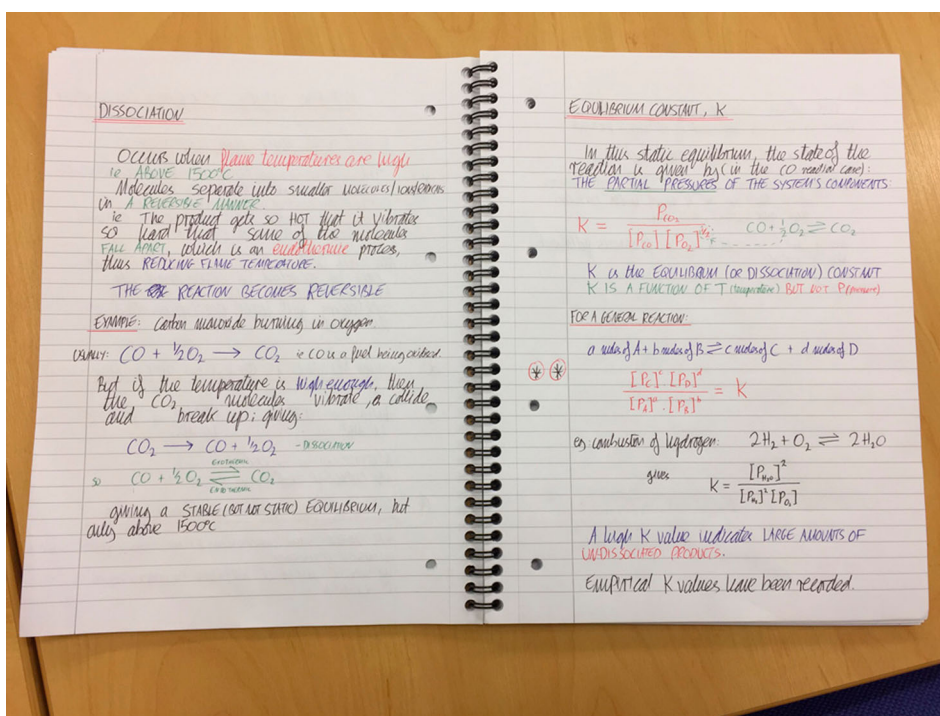


Figure 7. Example of notes taken by student participant 2.

affordances of lecture capture, such as the possibility to stop and rewind the recordings, provide students with control over their learning and allows for extensive note-taking (Elliott & Neal, 2016; Nordmann et al., 2018). However, a sociomaterial approach can advance perspectives by emphasising that lecture capture note-taking is an assemblage of many heterogeneous actants, not just the between the technology and student, but involves elements such as multimodal buttons, notepads, pens, rulers, websites, and past examination papers. Any of these actants can influence the workings of the assemblage. Moreover, each research participant engaged in practices of enmeshing analogue and digital media, as illustrated in Vignette 1. Interestingly, each participant exhibited a preference to making handwritten notes, which can be viewed as “embodied inscription practice” (Gourlay & Oliver, 2018, p. 88), and may suggest a desire for learners to handle and interact with physical objects as well as engage with digital media.

Lecture capture and spatiotemporal (re)configurations

The materiality of the lecture capture artefact enrolls the knowledge, practices, and discourses from distant space-times that constructed the original lecture event, which extend into the lecture space, and mediate its composition and interactions (e.g. AV technologies, lecture capture software, university timetable, curriculum, textbooks, the PowerPoint file, the lecturer’s understanding, students’ knowledge). Inseparably, the materiality of the lecture capture artefact also assembles the relational technologies (e.g. devices, video codecs, programming languages and code, icons, text, audio) responsible for successful playback of the event recording over networked connections. As an immutable mobile, the lecture capture can extend the spatiality of the original lecture event into new environments, and help assemble and translate new actor-network configurations, as illustrated by the following vignette:

I combine it [watching lecture recordings] with going to a café, going to a library, or to my place to study. What I don't want it to be is just go to café for study, or just go to the library. I need to change the environment because I get bored. If I'm just in a library everything is so quiet. I can't just be with everyone not talking. Sometimes when I decide to be in my room it is because I want to be in my pyjamas and be in my bed reading. (Vignette 2; Student participant 3)

The relational technologies involved in the playback of lecture recordings permit such fluid movements between heterogeneous actor-network configurations, whereby teaching and learning is not confined as taking place in enclosed or contained spaces.

Analysis of the produced visualisations supports the view that practices involving the lecture capture artefact operate within and across *hybrid spaces* (Farrell & Holkner, 2004; Thompson, 2012b) – temporally, spatially, and relationally – whereby there is a meshing of physical and virtual spaces mediated by a range of actors. For example, the same lecture capture artefact has the potential to extend into different physical environments, such as libraries, cafés, and bedrooms (Vignette 2), whereby each and every playback of the session will offer a unique sociomaterial construction. However, despite the notions of fluidity and mobility described in Vignette 2, all of the student-produced screen recordings collected in this study took place within the home environments of the participants (Figures 8 and 9). Vignette 3 points to pre-constructed study routines, whereby the participant has negotiated study practices within the spatiality of familiar environments.

That was my bedroom as I've got a shared student house. I could go in the living room I suppose but people come and go through there. So, no. I do all my study in the house in my room at my desk. (Vignette 3; Student participant 2)



Figure 8. Photograph of study environment, provided by student participant 1.

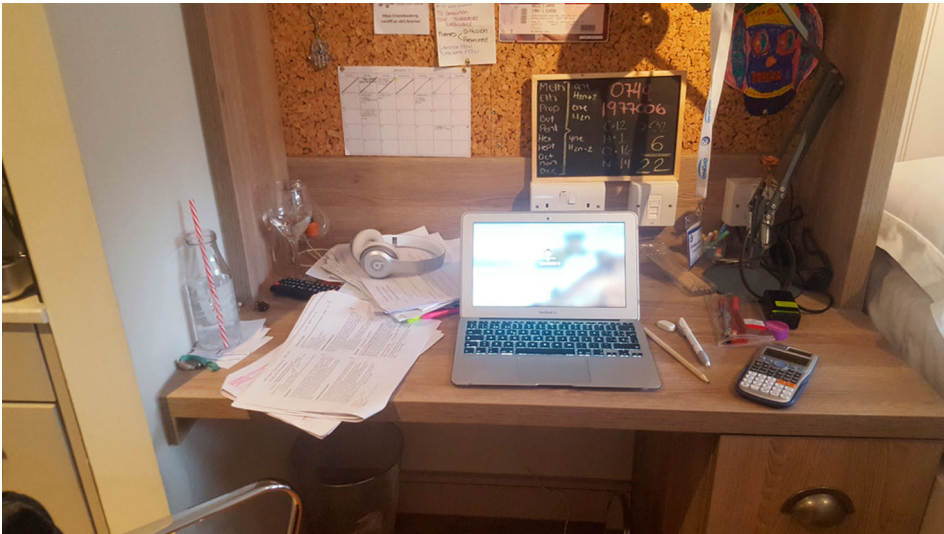


Figure 9. Photograph of study environment, provided by student participant 3.

Despite the notions of “anytime, anywhere” access associated with lecture recording (Morris et al., 2019), this study reveals that students may be markedly sensitive to location and their study assemblages require careful attention, crafting and arrangement (Gourlay & Oliver, 2018). Extending this, as Thompson (2012b) observes, despite the promise of the mobility of learning technologies, to learn efficiently some stability and predictability is required. For example, assembling the study practices associated with reviewing a recorded lecture required reliable connectivity to the Internet, and ample room to amass and organise physical actants (e.g. textbooks, note-books, pens, calculators, rulers, worksheets).

To advance perspectives and gain nuanced perspectives into how these actors (dis)connect and mediate the study practices of students, across different environments, a sociomaterial examination of the workings of the lecture capture artefact is now offered.

Fluidity and the pause/play actor-network

The student participants engaged in blended learning practices, negotiating multi-spatial environments, whereby the affordance of multitasking and fluid switching between contrasting actor-applications was a significant activity. The playback of the lecture recordings took place within the multifunctional spatiality of the computer screen (Decuyper & Simons, 2016b), which competed for positioning amongst various other actors, such as websites, the VLE, electronic documents, software applications, web browsers, anti-virus software, and media players. Moreover, any of these actors carried the potential to interrupt learning activities at any given time, for example via an update request or service notification.

Analysis of the student-produced videos revealed that the practice of pausing and resuming the lecture recording in order to carry out specific tasks, such as note-taking or visiting webpages, was frequency used by all participants. When the lecture recording is first opened the synchronised audio/video begins playing automatically and the “pause” icon is displayed within the navigation panel. Upon interaction and clicking of the “pause” icon, the state of the button changes to that of a “play” symbol (Figure 10). The play/pause button communicates through digital codes, co-ordinating actions with other actors. When paused, the video source and the screen capture freeze in place. The progress bar and the timestamp code halt. The audio of the capture stops transmitting

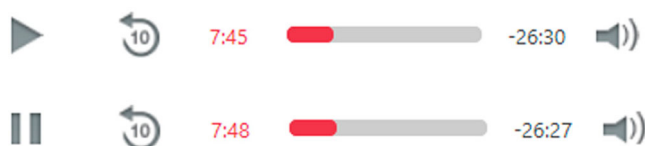


Figure 10. Lecture recording navigation bar. Top row displays the play icon (depicting pause state of recording). Bottom row displays the pause icon (depicting play state of recording). Reproduced with permission of the publisher, © Panopto.

via the computer speakers. Similar to Thompson's (2012a) observations concerning the keyboard "delete" button, it can thus be seen that the pause/play button enrolls other actants in performing specific functions. It is an assemblage and a complex arrangement of hardware, software, commands, semiotic signs, networks, and codes working discreetly when activated.

Exploring the ubiquitous use of semiotic devices, such as graphical symbols and icons to represent multimedia controls, suggests that the play/pause button can also be considered an immutable mobile. A triangle to represent "play" and parallel lines for "pause" can be viewed as "contemporary signage" (Gall & Breeze, 2005, p. 421), whereby they have become standardised icons by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). Their use can commonly be found on physical devices and application software, such as web-based media players, DVD/Blu-ray players, remote controls, multimedia keyboards, and software interfaces. It is reported that the symbols date back to the 1960s and were used as tape transport symbols on reel-to-reel tape decks (Gardiner, 2010). In this actor-network, the play icon was originally designed to represent the direction that the tape would move, via the orientation of the arrow. ANT perspectives illustrate how these icons have become stabilised and predictable black boxes (Callon, 1986), yet are highly mobile, able to detach themselves from their origins. The icons have become so entrenched in many heterogeneous networks that they have become an accepted standard in representing and enacting a specific action – that of "playing" or "pausing" – which is instrumental in producing networked relational effects.

Analysis of the student-produced videos revealed that each participant interacted and clicked on the play/pause icon a total of 15 times on average. In doing so, the practice of pausing the lecture capture afforded learners the opportunity to interact with digital actants (e.g. web browser tabs, VLE areas, online past examination papers, online search engines, websites) and physical instruments (e.g. handouts, notebooks, pens, rulers). The actor-network of the play/pause button functioned as a "valve" (Thompson, 2012a, p. 101) to mediate between a person, online/offline spaces, and study practices. Moreover, the play/pause button functioned to "presence" and "absence" other actors (Law & Singleton, 2005) and in doing so "configures spaces for pedagogic purposes" (Thompson, 2012a, p. 101). The material practices afforded by the play/pause button shaped interactions with the lecture capture, and enacted online and offline learning practices in particular ways. Such practices would fall apart if the button itself was absent and students were unable to pause/resume recordings.

The assemblage of the pause/play button also acted as a barrier against information overload, whereby the use of the pause button was instrumental in helping to consolidate new knowledge:

I'll start watching. If someone comes in and starts cooking, you can't hear it, so you'll just stop. Take a break, and then you start again. Which is probably for the best because watching for a whole hour isn't the best way of doing it. You turn off part the way through and yeah you just get bored. Whereas doing smaller sections, you actually know what's going on. Which is why, in the actual lectures, I don't particularly like them, and why I don't try and do anything otherwise you get overloaded and lose track. (Vignette 4; Student participant 1)

Such perspectives point towards studying practices which are in a constant state of negotiation, between conflicting actor-networks as well as network effects such as boredom. As discussed, the play/pause button was instrumental in forming "assemblages of relations" (Law, 2012, p. 157),

(dis)connecting other actants through oscillations between absence and presence, affording each student to assemble learning practices differently. All three students had multiple web browser tabs and applications open whilst playing the lecture capture artefact. The pause/play button allowed fluid movement between the spatiality of the screen and across applications, which delivered multiple performances in this study, not all of which can be viewed as harmonious with study practices. For example, the use of the pause button afforded one student the ability to switch between the lecture capture and a social networking site, where they engaged in an informal group conversation. For another learner, the pause button allowed them to check an incoming message on a mobile phone. Therefore, within these sociomaterial study practices it can be seen that the pause button served conflicting qualities. It brought to presence worthy and credible actants for studying (e.g. pens, notepads, handouts, relevant webpages, past examination papers), but also mobilised actors capable of disrupting network activity (e.g. mobile phones, social media sites, music players).

The following quote illustrates how one student navigated, negotiated, and disconnected from various actor-networks that encircled them, in an attempt to assemble sociomaterial networks most conducive for learning:

I'm quite easily distracted by FaceBook or Whatsapp [social networking platforms]. If a message comes through or something, then there's a little notification comes on your computer. I find that very distracting, so I know I turn them all off. And the same as on my telephone. They are turned off as well. So, I have to decide I am going to look at this now instead of those apps or things grabbing my attention. (Vignette 5; Student participant 1)

However, it should be noted, whilst cognitions and reasoning provided by the participants can be captured, analysed and interpreted, neither mentalist nor materialist reasons account for human actions; they are hybrids of both (Latour, 1986). ANT reminds us that human accounts of actions are influenced by complex domains, grounded in the cognitions of the person, for example beliefs, values and assumptions, as well as directly emergent from the physical world in which they interact.

Discussion

This paper reports on how students use recorded lectures in authentic scenarios. It is reported that students use recorded lectures to serve different purposes (Nordmann & McGeorge, 2018), and this study reveals that reviewing recordings for exam preparation was supported and supplemented by various other sociomaterial practices, distributed widely across space and time. Importantly, the observed study practices materialised within emergent connections and partially through the ad-hoc use of available artefacts, such as external websites, VLE documents, past examination papers, and handouts. Moreover, the sociomaterial agency of the lecture capture artefact permitted unpredictable interactions whereby students seamlessly transitioned between spaces, such as social networking platforms, mobile phones, and online media players. Recent literature suggests that learners struggle to multitask effectively and learners task switch which negatively impacts learning (Kirschner & De Bruyckere, 2017). The nuanced insights provided by ANT sensitivities in this study can illuminate the complex, messy, and dynamic situations that produce conditions which are more or less supportive for learning. Such perspectives also suggest entangled learning states whereby bifurcations between formal and informal learning are weakened (Kumpulainen & Sefton-Green, 2012; Zürcher, 2015). These are important insights; educationists, technologies, and environments should pursue ways of attending to this complexity (Goodyear & Carvalho, 2013).

Conceiving practices as enacted through sociomaterial relations commands attention to how space and time are (re)configured (McGregor, 2004; Murdoch, 1998). The use of the pause button enacts time as a persistent switching between different activities. Spatially, these different performances enact space as being something multifunctional, accessible via the use of the pause/play actant. Middleton (2016) positions audio recordings as flexible learning spaces, capable of connecting

academics and students beyond formal study spaces. Similarly, the lecture capture artefact can be seen as a rich, multimodal learning space, connecting various actors, unconstrained by time or place. Moreover, as an immutable mobile the lecture capture recording can extend the spatiality of the original lecture event into new locations, and help assemble and translate new actor-network configurations. In doing so, it is postulated that space and time are folded and (re)configured in the practice of lecture recording, forming the sociomaterial construction of the “hybrid” educational actor (Perrotta, Czerniewicz, & Beetham, 2016), held together by innocuous but powerful actors such as the play/pause button. Furthermore, the temporal dimensions of the lecturer can be significantly altered by capture technologies, whereby their voice and actions can be paused, replayed, stopped, and even accelerated. As such, ANT demonstrates that we cannot assume that the same network effects of knowledge distribution and pedagogy are translated verbatim during the process of lecture recording and subsequent reviewing by students. As Fenwick and Edwards (2010) argue, “pedagogical encounters change radically when its things change” (p. 5). These insights have important implications for how teaching and learning is conceived, and reveals the intricacies encircling lecture recording.

Exploring the compositional aspects of multimedia learning objects, as mediators for connecting and enacting sociomaterial learning practices beyond the environment of the actual object, has important implications for how future interactive objects and learning environments are designed. Importantly, this shifts perspectives away from considering learning technologies as being isolated from authentic and emergent practices, whereby attention is focused solely on presentational design or “affordances” of an artefact or environment (Wright & Parchoma, 2011). Rather, focus should be directed to understanding learning technologies through the “emergent design of technology-in-use” (Johri, 2011, p. 212) and studied holistically as an “embedded practice” (Sørensen, 2009, p. 79). Moreover, ANT positions learning as a network effect of materialising assemblages, and not only a cognitive achievement or way of interacting, whereby teaching and learning “do not exist and cannot be identified as separate from the networks through which they are enacted” (Fenwick & Edwards, 2010, p. 41).

Problematically, ANT does not offer a coherent framework and ANT-informed research is often messy and heterogeneous (Fenwick & Edwards, 2019). ANT is highly contested (e.g. Jones, 2016) but it is argued that the radical perspectives offered by ANT allow educationalists to appreciate the complexity of educational institutions and the active role of technology in this context (Hannon, 2012). If used practically, with a study focus, ANT can provide innovative analytical approaches into evaluating learning designs and a vocabulary for interpretations which helps dislodge pre-existing notions and thoughts. Indeed, ANT is perhaps best seen as a playful, “adaptable, open repository” (Mol, 2010, p. 253). Embracing this “open repository” philosophy, this study has deployed sensitivities offered from the domain of multimodality to explore the *performative* qualities of modes (Barad, 2003). In doing so, coupling ANT with multimodal analysis licenses researcher sensitivity towards viewing heterogeneous *modes* as *actors*. Adopting multimodal analysis may provide practical insights into how often overlooked modes of a text, such as icons, layout and framing (Kress, 2014), may become actors within an assemblage.

Conclusion

Ethnographically informed, this ANT study focused on local, narrative construction and sought to write descriptions of how networks come together and stabilise or fall apart, rather than create concrete interpretations of why (Latour, 2005). Producing visualisations provided valuable visual insights into the distributed areas of lecture capture practice and offered opportunities for scrutinising how practices are enacted, and the types of spaces produced. This paper has argued that technologies, such as lecture capture, are not produced in a vacuum, and space and time are entangled in complex ways throughout the production, distribution, and reviewing of recordings (Gourlay & Oliver, 2018).

In examining the student-led study practices, multitasking and task switching between contrasting actor-networks and spaces was a significant activity. Exploring an innocuous and ubiquitous practice, such as pausing, affords nuanced perspectives into the sociomaterial entanglements involved in enacting online pedagogy and learning across spatiotemporal dimensions (McGregor, 2004; Murdoch, 1998).

Moreover, adopting multimodal sensitivities, reveals how often overlooked modes (Kress, 2014), such as iconography, can become actors within an assemblage. Coupling ANT with multimodal sensitivities has uncovered how a pervasive everyday practice, such as pausing, can profoundly shape interactions and produce enactments of learning across different environments. Combining ANT with multimodality is little explored in ANT literature, and this may offer new insights into how modes help produce or stabilise configurations and advance efforts in attending to the non-human within actor-networks (Thompson & Adams, 2013).

This paper offers insights from a specific STEM undergraduate programme, at a UK Russell Group University, which is highly regulated by course attendance to lectures and course examinations. These actants had a profound mediating effect on the foci of this study. Although the findings may not be generalisable across academia, future studies could build upon the innovative approaches reported to undertake similar sociomaterial research across other disciplines and disciplines offering lecture capture. Whilst this study embraces the specificity of case study research, it would be particularly interesting to redeploy this novel methodology in other contexts, though any potential reuse of such methods will inevitably involve tracing different networks. Specifically, it would be of interest to investigate results from larger sample sizes of learners, across multiple disciplines, and explore the effects of different assessments and lecture content (e.g. didactic material based on information/theories or participatory/discussion based) on networked learning practices.

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No potential conflict of interest was reported by the author.

Notes on contributor

Karl Luke is a lecturer in Medical Education at Cardiff University. Prior to this position, Karl was responsible for the management and provision of the lecture capture service at the University. Karl was involved in designing, developing and implementing strategies to support both staff and students in using video capture technologies effectively for teaching and learning. Karl has also worked as a Learning Technologist at the University and has over 14 years' experience of designing for teaching and learning in a digital age. Karl's research interests include the use of video in higher education, multimodality and sociomateriality.

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